EXPLORING EARTH'S MYSTERIES
...PROTECTING ITS FUTURE

Brookhaven National Laboratory
Brookhaven LINAC Isotope Producer Facility

Facility Environmental Monitoring Report

Calendar Year 2001

BROOKHAVEN
NATIONAL LABORATORY

April 23, 2002

Prepared by:
D. Paquette, B. Hooda and M. Allocco
Environmental Services Division

GW63ER.02

Brookhaven National Laboratory
Brookhaven LINAC Isotope Producer
Facility Environmental Monitoring Report
Calendar Year 2001

Summary of Results:

During May-June 2000, BNL and DOE undertook additional protective measures by injecting a colloidal silica grout to reduce the permeability of the activated soils. However, groundwater monitoring conducted after the grout was injected indicated that the grout had displaced residual contaminated soil pore water. This contaminated water quickly entered the aquifer, and resulted in a short-term impact to groundwater quality in the BLIP area. By October 2000, tritium concentrations up to 56,500 pCi/L were detected in a well located approximately 40 feet downgradient of the BLIP target vessel. By the end of December 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard. Continued monitoring during 2001 was able to track the slug of contaminated groundwater to a distance of 150 feet downgradient of the BLIP facility. The maximum tritium concentration observed at this distance was 60,800 pCi/L in July 2001. Tritium concentrations declined to less than 20,000 pCi/L by November 2001.

During CY 2001, the average concentrations of the short-lived gaseous emissions were characterized as 2.32E+03 curies of carbon-11 and 7.15 E+3 curies of oxygen-15. The contribution to the effective dose equivalent from these emissions to the members of the public was 0.132mrem/ year. Although, there was an increase in the quantity of air emissions, this increase did not significantly impact the effective dose to members of the public because these radionuclides are in the form of gases that have short half-lives (O-15: 122 seconds; and C-11: 20.48 minutes). Tritium emissions for 2001 were in micro curie quantities. Although tritium has half-life of 12.3 years, the release quantity was insignificant from a risk perspective.

Background

When the BLIP is operating, the LINAC delivers a 200 MeV beam of protons that impinge on a series of eight targets located within the BLIP target vessel. During irradiation, the BLIP targets are located at the bottom of a 30-foot underground tank. The targets rest inside a water-filled 18-inch diameter shaft that runs the length of the tank, and are cooled by a 500 gallon closed loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and activation of the soils immediately outside of the tank occurs due to the creation of secondary particles produced at the target. Air emissions from the BLIP facility pass through a HEPA

filtration system. Following filtration, small quantities of oxygen-15 and tritium are released to the atmosphere.
As part of a 1985 redesign of the vessel, leak detection devices were installed, and the open space between the water filled shaft and vessel's outer wall is used as secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements, and is registered with SCDHS. The BLIP facility also has a 500 gallon-capacity UST used for liquid radioactive waste (change out water from the BLIP primary system). The waste tank and its associated piping system conform to Article 12 requirements, and are registered with SCDHS.

In 1998, BNL conducted an extensive evaluation of groundwater quality near the BLIP facility. Tritium concentrations of 52,000 pCi/L and sodium-22 up to 151 pCi/L, were detected in a temporary well installed approximately 50 feet downgradient of the BLIP target vessel. Elevated levels of tritium (11,400 pCi/L) and sodium-22 (at 38 pCi/L) were also detected in shallow groundwater samples collected from a temporary well that was installed 150 feet downgradient of the BLIP. Due to the activation of soils and the detection of tritium and sodium-22 in groundwater, the BLIP facility has been designated as AOC 16K under the Environmental Restoration program.

Starting in 1998, BNL made improvements to the stormwater management program at BLIP in an effort to prevent rainwater infiltration of the activated soils below the building. The BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive gunnite (cement) cap was installed on three sides of the building. In May-June 2000, BNL undertook additional protective measures by injecting a colloidal silica grout into the activated soils. The grout reduces the permeability of the soils, thus further reducing the potential of rainwater leaching radionuclides out of the soil and into groundwater.

Environmental Monitoring Program

As required by DOE Order 5400.1, BNL has established an environmental monitoring program at the BLIP facility to evaluate potential impacts to environmental quality from its operation, and to demonstrate compliance with DOE requirements and applicable federal, state and local laws and regulations.

The environmental monitoring program for the BLIP facility is described in the BNL Environmental Monitoring Plan (Daum *et al*. 2000 and BNL, 2001). The monitoring programs are summarized below.

Monitoring Results

Groundwater

During 1999 and early 2000, seven new groundwater monitoring wells were installed as a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality.

As noted in the CY 2000 monitoring report (BNL, 2001), groundwater monitoring data collected from January 1999 to July 2000 indicated that the corrective actions taken during 1998 were highly effective in preventing the release of tritium and sodium-22 from the activated soils surrounding the BLIP target vessel. However, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples collected after the silica grout injection process in late May-early June 2000. Samples collected in early July indicated tritium and sodium-22 concentrations of 5,700 pCi/L and 57 pCi/L, respectively. By early October, groundwater data indicated tritium concentrations increased to a maximum of 56,500 pCi/L in samples from monitoring well 064-67, located approximately 40 feet downgradient of the BLIP vessel. In accordance with the BNL Groundwater Contingency Plan, BNL and DOE notified the regulatory agencies of this situation and increased the groundwater sampling frequency to bi-weekly. At the request of the agencies, the well sampling frequency was increased to weekly starting December 1, 2000. The maximum sodium-22 concentration was 299 pCi/L detected in Well 064-67 on December 1, 2000. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard in wells located approximately 40 feet downgradient of BLIP, and weekly sampling of the wells was discontinued by the end of January 2001. Tritium concentrations in these wells did not exceed 7,000 pCi/L during 2001. As the slug of tritium continued to migrate downgradient of BLIP, concentrations in Well 064-50 increased to 20,000 pCi/L by December 28, 2000. Well 064-50 is located approximately 150 feet downgradient of BLIP. Well 064-50 was sampled monthly during 2001 (Table 1). Tritium concentrations in Well 064-50 reached a maximum of 60,800 pCi/L in July 2001, and then declined to less than 20,000 pCi/L by November 2001 (Figure 3). There was good correlation between modeled and observed tritium concentrations in Well 064-50, and it is expected that peak tritium concentrations in the plume will drop below the drinking water standard at all locations by September 2002 (Sullivan, 2001)

Post-Grouting Assessment: Following the detection of elevated tritium concentrations in October 2000, BNL conducted a review of the grouting process. Findings of this review suggest that that grout displaced residual vadose zone soil pore water that was contaminated with tritium. The pattern of decreasing tritium concentrations in wells directly downgradient of BLIP indicate a short-term (pulsed) tritium release and that the plume has dissipated quickly in the aquifer. Although the grouting process had a short-term impact on groundwater quality, it is believed that the process will provide long-term benefits in reducing the permeability of the contaminated soil shielding. Information on the potential for displacing residual pore water will be used to improve this innovative grouting technology.

Air Monitoring

Air emissions from the BLIP facility pass through a HEPA and charcoal filtration system before being released through a 16-meter stack. Air emissions are monitored by fixed, continuously operating sampling devices: silica gel to sample tritiated water vapor, a particulate matter filter (0.3 microns) for analysis of gamma-emitting radionuclides, and a TEDA-loaded charcoal cartridge for radioiodine detection. Radiological gases emissions, such as oxygen-15, and carbon-11, are estimated by the fluence rate and hours of machine operation in micro-ampere-hours. The conversion factor and measured activity (i.e., mCi/micro-ampere-hrs) are used in estimating the curies of emissions. The conversion factor used prior to CY 2000 was 0.30 mCi/uA-hrs.

In CY 2001, the average concentrations of the short-lived gaseous emissions were characterized as 2.32E+03 curies of carbon-11 and 7.15 E+3 curies of oxygen-15. The contribution to the effective dose equivalent from these emissions to the members of the public was 0.132 mrem/year. These emissions did not significantly impact the effective dose to members of the public because these radionuclides are in the form of gases that have very short half-lives (O-15: 122 seconds; and C-11: 20.48 minutes). The increase was due to an increased period of operation for BLIP and a re-characterization of air emissions from the facility; namely the identification of C-11 as an effluent.

Tritium air emissions for the calendar year 2001 were in the micro curie range, and posed insignificant dose consequences. The air emissions were well below the derived concentration guide limits for the members of the public. Therefore, it can be safely concluded that there was negligible impact to the environment from air emissions from BLIP operations.

Future Monitoring Actions

It is recommended that:

- Groundwater samples should continue to be collected quarterly until CY 2003. Samples should be collected quarterly for tritium analyses and semiannually for gamma spectroscopy (to evaluate Na-22 concentrations).
- Starting in CY 2003, groundwater monitoring schedule should be reduced from quarterly to semiannually.
- The air monitoring program will be continued at its current level with improved sampling, analytical methods, and data verification and validation.
- A proposal with recommended sampling frequency and monitoring for the short-lived gases should be made to the Environmental Protection Agency because the effective dose equivalent to member of the public is at 1% of the NESHAPs standard.

References

BNL, 2001. Brookhaven National Laboratory Environmental Monitoring Plan, CY 2001 Update (January 2001). BNL-52584 (Update).

Daum, M., Dorsch, W., Fry, J., Green, T., Lee, R., Naidu, J., Paquette, D., Scarpitta, S., and Schroeder, G., 2000. Brookhaven National Laboratory, Environmental Monitoring Plan 2000 (March 31, 2000). BNL-52584.

Sullivan, T., 2001. Revised Modeling of the BLIP Tritium Plume. BNL Memorandum to D. Bennett dated October 4, 2001.

BNL Facility Groundwater Monitoring Program

Brookhaven LINAC Isotope Producer (BLIP)
Summary of Tritium and Sodium-22 Results for CY 2001
(pCi/L)

Well	Radionuclide	January 4-5	January 11	January 18	January 25
64-46 (upgradient)	Tritium Sodium-22	<324 ND	NS	NS	NS
54-61 (upgradient)	Tritium Sodium-22	<308 ND	NS	NS	NS
64-47 (~40 feet downgradient)	Tritium Sodium-22	508 +/- 212 ND	701 +/- 245 2.8 +/- 1.5	629 +/- 243 2.0 +/- 0.9	646 +/- 212 3.2 +/- 1.1
64-48 (~40 feet downgradient)	Tritium Sodium-22	977 +/- 223 9.4 +/- 1.6	1,530 +/- 283 9.9 +/- 1.7	1,760 +/- 297 9.9 +/- 1.7	1,580 +/- 251 10.8 +/- 1.8
64-67 (~40 feet downgradient)	Tritium Sodium-22	10,400 +/- 499 149.0 +/- 11.2	12,200 +/- 585 132.0 +/- 10.2	11,700 +/- 577 111.0 +/- 8.8	7,790 +/- 445 99.8 +/- 7.8
64-49 (~150 feet downgradient)	Tritium Sodium-22	<308 ND	NS	NS	NS
64-50 (~150 feet downgradient)	Tritium Sodium-22	<308 23.7 +/- 2.7	13,500 +/- 613 26.7 +/- 2.8	18,600 +/- 710 27.7 +/- 3.1	9,100 +/- 485 24.6 +/- 2.8
64-02 (~450 feet downgradient)	Tritium Sodium-22	NS	NS	NS	NS

ND: Radionuclide not detected.
NS: Well not sampled during this period.
Note: Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

BNL Facility Groundwater Monitoring Program

Brookhaven LINAC Isotope Producer (BLIP)
Summary of Tritium and Sodium-22 Results for CY 2001
(pCi/L)

Well	Radionuclide	February 27	March 12	March 28	April 10
64-46 (upgradient)	Tritium Sodium-22	NS	NS	NS	<323 ND
54-61 (upgradient)	Tritium Sodium-22	NS	NS	NS	NS
64-47 (~40 feet downgradient)	Tritium Sodium-22	574 +/- 238 8.0 +/- 1.8	NS	NS	348 +/- 226 14.9 +/- 1.9
64-48 (~40 feet downgradient)	Tritium Sodium-22	2,050 +/- 308 12.8 +/- 2.1	NS	NS	3,900 +/- 377 74.8 +/- 6.7
64-67 (~40 feet downgradient)	Tritium Sodium-22	5,730 +/- 437 106.0 +/- 8.4	NS	NS	751 +/- 246 32.4 +/- 3.7
64-49 (~150 feet downgradient)	Tritium Sodium-22	NS	NS	NS	NS
64-50 (~150 feet downgradient)	Tritium Sodium-22	11,700 +/- 582 24.8 +/- 2.8	16,000 +/- 631 30.6 +/- 3.3	20,700 +/- 737 64.8 +/- 5.9	28,300 +/- 872 101 +/- 8.3
64-02 (~450 feet downgradient)	Tritium Sodium-22	NS	NS	NS	NS

ND: Radionuclide not detected.
NS: Well not sampled during this period.
Note: Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

BNL Facility Groundwater Monitoring Program
Brookhaven LINAC Isotope Producer (BLIP)
Summary of Tritium and Sodium-22 Results for CY 2001
(pCi/L)

Well	Radionuclide	April 27	June 20	July 23	August 28
64-46 (upgradient)	Tritium Sodium-22	NS	<337 ND	NS	NS
54-61 (upgradient)	Tritium Sodium-22	NS	NS	NS	NS
64-47 (~40 feet downgradient)	Tritium Sodium-22	NS	<337 6.9 +/- 1.4	NS	NS
64-48 (~40 feet downgradient)	Tritium Sodium-22	NS	4,640 +/- 427 22 +/- 2.6	NS	NS
64-67 (~40 feet downgradient)	Tritium Sodium-22	NS	3,920 +/- 402 15.6 +/- 2.1	NS	NS
64-49 (~150 feet downgradient)	Tritium Sodium-22	NS	NS	<364 ND	NS
64-50 (~150 feet downgradient)	Tritium Sodium-22	33,700 +/- 837 143 +/- 10.9	35,800 +/- 1,040 188 +/- 14.6	60,800 +/- 1,300 304 +/- 25	53,500 +/- 1,100 337 +/- 23.7
64-02 (~450 feet downgradient)	Tritium Sodium-22	NS	NS	<365 ND	NS

ND: Radionuclide not detected.
NS: Well not sampled during this period.
Note: Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

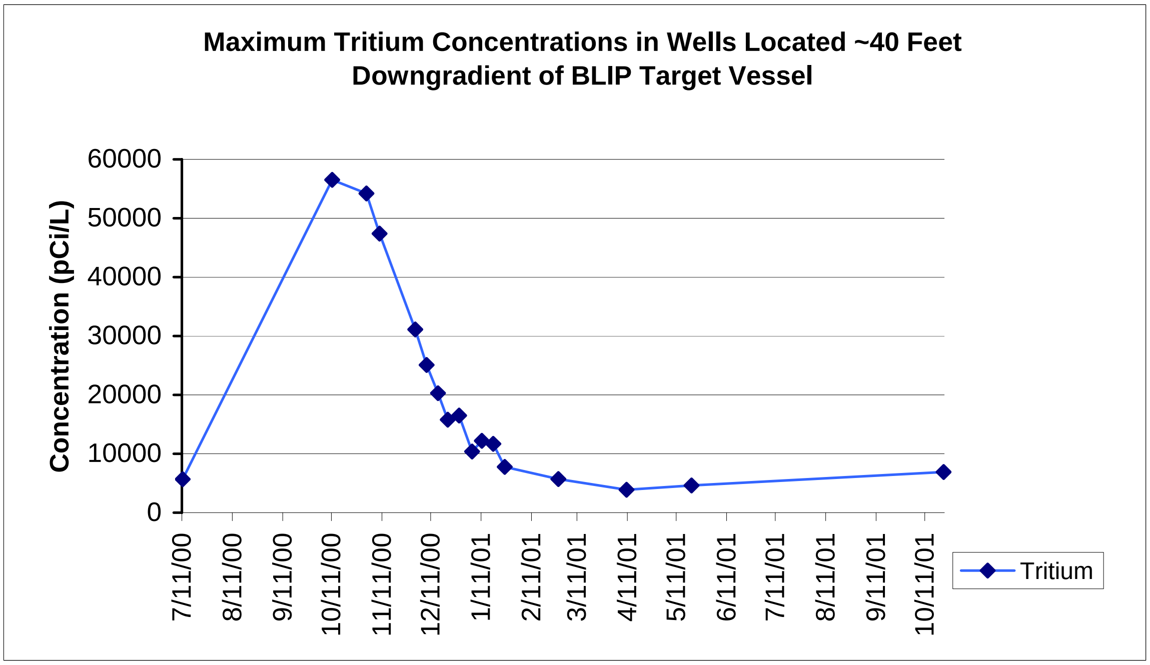
BNL Facility Groundwater Monitoring Program

Brookhaven LINAC Isotope Producer (BLIP)
Summary of Tritium and Sodium-22 Results for CY 2001
(pCi/L)

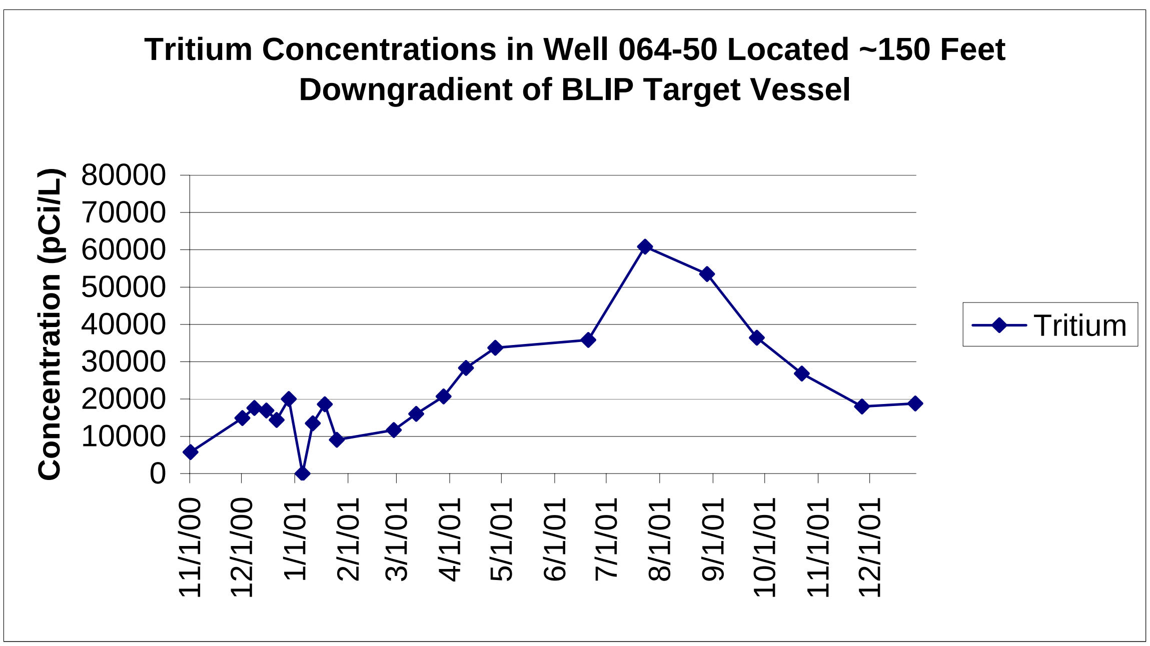
Well	Radionuclide	September 26	October 22	November 26	December 27
64-46 (upgradient)	Tritium Sodium-22	NS	<397 ND	NS	NS
54-61 (upgradient)	Tritium Sodium-22	NS	NS	NS	NS
64-47 (~40 feet downgradient)	Tritium Sodium-22	NS	<409 3.6 +/- 1.3	NS	NS
64-48 (~40 feet downgradient)	Tritium Sodium-22	NS	2,310 +/- 340 4.7 +/- 1.4	NS	NS
64-67 (~40 feet downgradient)	Tritium Sodium-22	NS	6,920 +/- 499 78 +/- 6.3	NS	NS
64-49 (~150 feet downgradient)	Tritium Sodium-22	NS	NS	NS	NS
64-50 (~150 feet downgradient)	Tritium Sodium-22	36,400 +/- 1,090 275 +/- 19.6	26,800 +/- 902 245 +/- 19.7	18,000 +/- 663 269 +/- 23	18,800 +/- 810 NA
64-02 (~450 feet downgradient)	Tritium Sodium-22	NS	NS	NS	NS

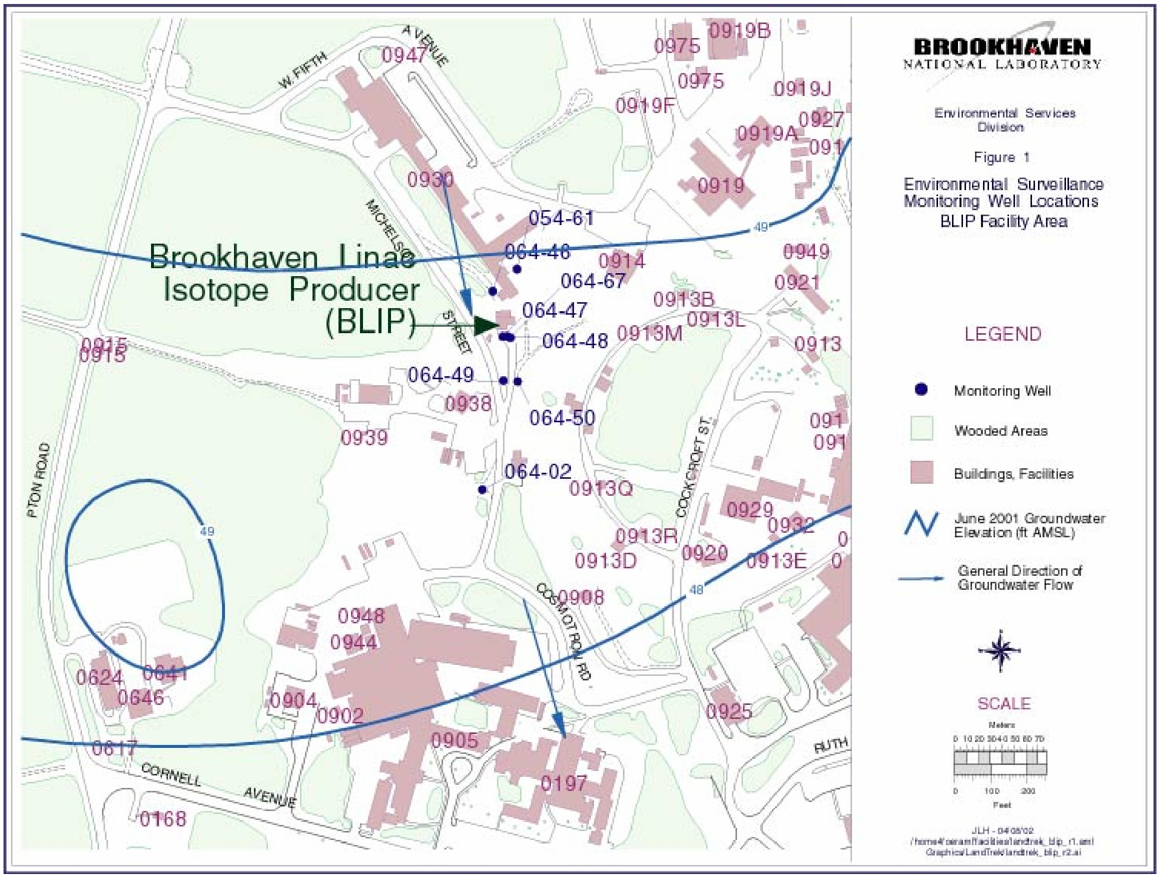
NA: Not analyzed for this radionuclide.
ND: Radionuclide not detected.
NS: Well not sampled during this period.
Note: Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

BNL Facility Environmental Report
Brookhaven LINAC Isotope Producer
Tritium and Sodium-22 Concentration Trends in Groundwater during CY 2000-2001
Figure 2



BNL Facility Environmental Report
Brookhaven LINAC Isotope Producer
Tritium and Sodium-22 Concentration Trends in Groundwater during CY 2000-2001
Figure 3




BROOKHAVEN NATIONAL LABORATORY
Environmental Services Division
Figure 1
Environmental Surveillance Monitoring Well Locations BLIP Facility Area
LEGEND
Monitoring Well
Wooded Areas
Buildings, Facilities
June 2001 Groundwater Elevation (ft AMSL)
General Direction of Groundwater Flow
SCALE
Meters
Feet
Brookhaven Linac Isotope Producer (BLIP)
054-61
064-46
064-67
064-47
064-48
064-49
064-50
064-02
W. FIFTH AVENUE
MICHELSON STREET
COCKCROFT ST.
COSMOTRON RD
CORNELL AVENUE
RUTH
49
48